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Zinc-fertilization effects on wheat yield and yield components

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Abstract
A field experiment was conducted in Department of Soil Science and Agricultural Chemistry, BAU, Ranchi during *rabi* season 2012- 13 and 2013-14. The objectives were to evaluate the effect of zinc (Zn) on the yield and yield contributing characters of wheat and to find out the optimum dose and method of Zn application for yield maximization. The treatments consisted of control (T_0), 5 kg Zn ha^{-1}(T_1), 10 kg Zn ha^{-1} (T_2) and 5 kg Zn ha^{-1} + 2 foliar sprays (T_3). The basal dose of NPK at the rate of 120: 60: 40 kg ha^{-1} respectively, was applied to all treatments. The treatments were arranged in randomized complete block design with three replications. Results showed that effect of Zn application was significant on the grain yield (q/ha), straw yield (q/ha), and sterility percentage but had no effect on spike length, thousand grain weight and harvest Index. Average grain yield of two years is highest (3.93 t/ha) under the combination of soil and foliar application of Zn and lowest yield (3.36 t/ha) in control is observed. Maximum reduction in sterility percentage was found in soil along with foliar application of Zn. Based on the findings of study combined application of basal and foliar Zn on wheat may increase the grain yield.

Keywords: foliar application, wheat, yield, yield component and zinc

Introduction

India occupies 329 million hectares of land and area wise it ranks seventh in the world with 17% population and 2.5% world area. Omnibus signs are that by 2050 India will become the most populous nation in the world. These become a great challenge to fulfill the demand by increasing the food grain quality and production. Efficient fertilizer management is very important factor to enhance the yield potential.

Soil fertility is an important factor, which decides the growth of plant. It is determined by the presence or absence of nutrients i.e. macro and micronutrients. The availability of micronutrients is very dependent on soil environment. The factors that affect the availability of micronutrients are organic matter, soil pH, lime content, sand, silt and clay contents revealed from different research experiments. The reason behind the depletion of soil fertility in India are mainly intensive cropping system, imbalanced use of fertilizer, application of macronutrient alone and ignorance of micro nutrients and organic manures.

Zinc an essential element for the normal growth and development of plants. It plays vital role in enzyme activation and also involved in the biosynthesis of some enzymes and growth hormones (Marschner, 1995). Zinc deficiency is a very important nutrient problem in the Indian soils. Total Zn concentration is sufficient in many agricultural areas, but available Zn concentration is deficient because of different soil and climatic conditions. Soil pH, lime content, organic matter amount, clay type and amount and the amount of applied phosphorus fertilizer affect the available Zn concentration in soil (Adiloglu & Adiloglu, 2006) [2].

In soil Zn deficiency is very common in cereal based cropping system (Cakmak, 2002) [4]. Zinc deficiency is a prevalent micronutrient deficiency in wheat, leading to severe reduction in wheat production and nutritional quality of grains (Cakmak *et al*., 1996) [5].

Wheat is the most widely grown cereal crop in the world and as a staple food it is second only to rice in consumption. Generally, the regions with severe zinc-deficient soils are also the regions where zinc deficiency in human beings is very common. Therefore, there is a great need to improve cereal crops with adequate zinc nutrition.

The application of macro and micronutrients fertilizer in the cultivation zone may not be fulfilling the crop requirement. The alternative approach is to apply these nutrients as foliar sprays. Soil plus foliar applications of micronutrient have been reported to be equally or even more effective as soil application (Firdous *et al*., 2016) [6]. Foliar application lead to increase in grain yield components in wheat showed increase in yield components by application of micronutrients (Boorboori *et al.*, 2012) [3, 10].

The present study was, therefore, undertaken (i) to evaluate the response of Zn on the yield and yield contributing characters of wheat, and (ii) to find out a suitable dose of Zn for the maximization of wheat yield.

Methods and Materials

A field experiment was conducted during 2012-13 and 2013-14 at Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Ranchi, Jharkhand. The soil used in the experiment belongs to Alfisol. Before imposition of zinc treatments, the soils used in the experiment had the following properties viz., pH 4.68, EC 0.395 dSm^{-1}, organic carbon 0.41%, KMnO4-N 330 kg ha-1, Bray –P1 30.63 kg ha^{-1}, NH4OAc- K 140.5 kg ha^{-1} and DTPA Zn 1.08 mg kg^{-1}.

Four rates of zinc were applied and the rates are 0 (T_0), 5.0 (T_1), 10 (T_2) and 5 kg Zn ha^{-1} + 2 foliar sprays @0.5% of $ZnSO_4$. H_2O at tillering and before flowering stage (T_3). Half of nitrogen, total phosphorus and total potassium was applied as basal in the form of DAP, urea and MOP (120: 60: 40) at the time of sowing and one fourth of nitrogen was top dressed after 30 DAS and rest one fourth after 60 DAS in the form of urea in split doses as per treatment.

Soil samples were collected randomly from four different places from each plot and then made a composite sample. Soil analysis for zinc was done by DTPA method (Lindsay and Norvell, 1978). At maturity, weight of 1000 seeds, length of the spike, total number of grains per spike, number of unfilled grains per panicle has been counted. Grain yield and straw yield has been measured and sterility percentage and harvest index were calculated.

Result and discussion

Yield and harvest index

Grain yield (pooled data) revealed significantly superior grain yield under the levels of zinc application in T_3 over the T_0, T_1, and T_2. The response of crop to different levels of zinc application, in terms of grain yield seems to be positive. Boorboori *et al*., 2012 [3, 10] expressed that foliar application of zinc increased grain wheat yield. The increase in the grain yield is attributable to the improved physiology of plants with the added Zn consequently correcting the efficiency of different enzymes, chlorophyll content, IAA hormone and improvement in nitrate conversion to ammonia in plant leading to higher yield (Hacisalihoglu *et al*., 2003; Abbas *et al*., 2010) [7, 1]. Ranjbar and Bahmaniar (2007) [13] reported that soil and foliar application of Zn fertilizer alone were not as effective as soil alongwith foliar applications to increase yield.

The straw yield obtained under T_3 were significantly superior over T_0 and T_1 whereas at par with T_2. Straw yield were recorded to be 6.34, 6.78, 6.98 and 7.01 t ha^{-1} under T_0, T_1, T_2 and T_3 respectively. The straw yield under T_3 was significantly superior over T_0 and T_1 and at par with T_2. Keram *et al*., (2013) [9] also reported that the straw yield of wheat, was significantly increased with the application of zinc.

The harvest index an indicator of partitioning behavior showed a different trend than that observed in case of grain yield. The highest harvest index was recorded in case of T_0. However, the differences in harvest index were non-significant.

Yield component

The yield parameters having an overall reflection into the final grain yield assume great importance and hence the impact of different level of Zn application also seems to be worth analyzing the yield attributing parameters like total number of grains, number of unfilled grains, sterility percentage, spike length, and test weight recorded under different levels of Zn application have been presented in table 1 and discussed here under.

Spike length was recorded to be 9.4, 9.9, 10.0 and 10.2 cm under T_0, T_1, T_2 and T_3 respectively. The impact of different levels of Zn application on panicle length was non significant. The test weight an indicator of the boldness of individual grain was found to be improved non significantly in both the years of experimentation. Boorboori *et al*, (2012) [3, 10] and Moghadam *et al.* (2012) [11] reported that evaluated foliar spraying of Zinc element on wheat, have no marked effect on 1000 grain weight.

Total number of grains per panicle was found to increase non significantly under all the levels of Zn application. Ziaeyan *et al*., (2009) [16] was reported that either foliar or soil application of Zn could increase number of total grains per stalk. From the sterility point of view the levels of Zn application contributed towards reducing the sterility percentage, the values were recorded as 16.1, 14.2, 13.5 and 12.7% under T_0, T_1, T_2 and T_3 respectively. In terms of sterility percent reduction T_3 was significantly superior over control. The highest reduction recorded in case of T_3.

Zn content in grain and straw

The wheat grain Zn content was 40.9, 46.0, 48.3 and 52.6 mg kg^{-1} under T_0, T_1, T_2 and T_3, respectively. The level T_3, reflected into highest contribution towards grain Zn. The level T_3 being the most superior over control as well as over the rest of the level. Phattarakul *et al*., (2011) [12] reported that foliar application of Zn at panicle initiation was effective in increasing whole grain Zn contents two fold. As per the pooled analysis, Zn contents in straw at maturity were 21.9, 22.9, 23.9 and 25.1 mg kg^{-1} T_0, T_1, T_2 and T_3, respectively. The level T_3 and T_2 were significantly superior over control and the level T_1 being at par with control. Foliar application of zinc increased grain zinc concentration (Jiang *et al*., 2008; Stomph *et al*., 2011 and Zhang *et al*., 2012) [8, 14, 15]. Ranjbar and Bahmaniar, (2007) [13] reported that the lower effectiveness of soil and foliar applications in comparison with soil plus foliar applications of Zn fertilizer may be credited to lower levels of Zn in wheat shoot.

Soil Zn content

The soil Zn content was 2.15, 2.99, 3.66 and 4.31 mg kg^{-1} respectively under T_0, T_1, T_2 and T_3. All the levels of Zn application (T_1 to T_3) were significantly superior over the control. Level T_3 was found significantly superior over T_2 and over T_1 whereas T_2 was significantly superior over T_1.

Conclusion

Based on this research, it is concluded that the soil along with foliar application of Zn should be integrated to achieve both high grain yield and high grain Zn quality.

Table 1: Crop response to different levels of Zn application in wheat yield and yield components (pooled data)

Level of Zn application	Grain yield (t ha^{-1})	Straw yield(t ha^{-1})	Harvest index (%)	Sterility (%)	Spike length (cm)	1000 grain weight (gm)	Zn content (mg kg^{-1})		
							Straw	Grain	Soil
T_0	3.36	6.34	34	16.1	9.5	39.7	21.9	40.9	2.25
T_1	3.47	6.78	33.2	14.1	9.9	40.4	22.9	46	2.99
T_2	3.68	6.98	34.2	13.4	10	42.5	23.8	48.2	3.66
T_3	3.93	7.01	35.4	12.7	10.2	43	25.1	52.6	4.31
CD at 5 %	2.2	3.3	NS	0.7	NS	NS	1.5	1.5	0.1
CV %	7.3	5.8	4.7	6.2	7.2	7.6	7.7	3.7	3.52

T_0 - Control, T_1- 5.0 kg Zn ha^{-1}, T_2 – 10.0 kg Zn ha^{-1}, T_3 – 5.0 kg Zn ha^{-1} with two foliar applications

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